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STRESS CORROSION RESISTANCE OF 7010-T73651

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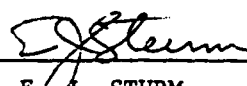
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TABLE OF CONTENTS

	PAGE
LIST OF TABLES	ii
LIST OF FIGURES	ii
INTRODUCTION	1
EXPERIMENTAL PROCEDURE	1
RESULTS AND DISCUSSION	2
CONCLUSIONS	2
REFERENCES	3

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L I S T O F T A B L E S

TABLE	TITLE	PAGE
I	PROPERTIES OF 7010 AND 7050 ALUMINUM ALLOYS.....	4
II	COMPARISON OF TEST RESULTS IN 3 1/2 PERCENT ALTERNATE IMMERSION TEST WITH 0.125 INCH DIAMETER SHORT TRANSVERSE TENSILE SPECIMENS.....	5

L I S T O F F I G U R E S

FIGURE	TITLE	PAGE
1	PHOTOMICROGRAPH OF 7010-T73651 FAILURE AFTER 28 DAYS ALTER- NATE IMMERSION TEST IN 3 1/2 PERCENT NaCl AT A STRESS LEVEL OF 25 ksi.....	6
2	PHOTOMICROGRAPH OF 7010-T73651 FAILURE AFTER 28 DAYS ALTER- NATE IMMERSION TEST IN 3 1/2 PERCENT NaCl AT A STRESS LEVEL OF 45 ksi (310 MPa).....	7
3	PHOTOMICROGRAPH OF 7050-T73651 AFTER 30 DAYS ALTERNATE IMMER- SION TEST IN 3 1/2 PERCENT NaCl AT A STRESS LEVEL OF 45 ksi...	8

I N T R O D U C T I O N

Under a development program initiated by the British Ministry of Defense, Alcan Laboratories and Alcan Plate Ltd. have produced an Al-Zn-Mg-Cu alloy with tensile strength similar to 7075-T6 but with purported improved resistance to stress corrosion cracking and exfoliation. Efforts are now underway to make the alloy, designated 7010, competitive with 7050 from a procurement standpoint. In 7010, zirconium has replaced chromium and the copper content is slightly lower at 1.5 to 2.0 percent instead of 2.0 to 2.6 percent as in 7050. It is purported that the stress corrosion resistance of 7010 and 7050 are very similar in the T73651 temper, both having passed a 30 day alternate immersion test at 35 ksi (240 MPa). Alcan provided a 3.2 inch (80 mm) thick plate of 7010-T73651 to the Naval Air Systems Command. The 7010 plate was shipped to McDonnell Douglas Corporation, St. Louis, Missouri where specimens were machined for mechanical property, stress corrosion, and exfoliation tests. A limited number of stress corrosion and exfoliation specimens were supplied to NADC for comparison testing. This work describes the tests performed on these specimens under AIRTASK ZF61-542-001, Work Unit ZM501.

E X P E R I M E N T A L P R O C E D U R E

MATERIALS

The 7010 material used in this comparative study was supplied in the form of 3.2 inch (80 mm) plate with the T73651 temper. Specimens were machined at McDonnell Douglas Aircraft Company for mechanical as well as corrosion testing. Nine short transverse 0.250 inch (6.35 mm) diameter tensile specimens and one 2 by 4 inch (50 by 100 mm) exfoliation specimen were sent to NADC for corrosion testing. All previous stress corrosion tests at NADC had employed 0.125 inch (3.18 mm) diameter tensile specimens. Stressing fixtures were, therefore, not available for testing 0.250 inch diameter so the 7010 specimens were remachined to 0.125. Specimens of 7050-T73651 machined from a 4 inch (100 mm) thick plate were included for comparison. Specimen type and stressing fixtures are given in ASTM G49 (reference (a)). The composition and tensile properties of both alloys are given in table I.

STRESS CORROSION TEST

The smooth 0.125 inch diameter tensile specimens of both 7010-T73651 and 7050-T73651 were subjected to the ASTM G47 alternate immersion stress corrosion test in 3.5 percent NaCl for 30 days (reference (b)). Triplicate specimens were loaded to stress levels of 25, 35, and 45 ksi (170, 240, and 310 MPa).

The entire assemblies were dipped in molten maskcoat No. 2 (oil-free cellulose acetate butyrate) so that only the specimen gauge lengths were exposed. The specimens were inspected daily for failure during the 30 day period and failed specimens removed from the test.

EXFOLIATION TEST

The flat specimen identified as 7010-2 was subjected to the ASTM G34 Exco test (reference (c)) for 48 hours. The back was masked to protect the identification of the specimen.

R E S U L T S A N D D I S C U S S I O N

The results of the alternate immersion stress corrosion test are given in table II, together with results from tests run at Alcoa (reference (d)). There were no failures of 7050-T73651 in 30 days. There was one failure each at 25 and 45 ksi for the 7010-T73651, both at 28 days. The failure of one 7010 specimen at 25 ksi was considered anomalous since there were no failures noted at 35 ksi. Correlation with results at Alcoa is very close. No comparison can be made with McDonnell Douglas results because of the difference in specimen size.

Metallographic examination of the failed specimens revealed cracks initiating from deep corrosion pits and propagating in intergranular and transgranular modes. Both the 7010 and 7050 showed this behaviour with the 7010 having deeper pits and extended incipient cracks as can be seen in the photomicrographs of figures 1 to 3.

Results of the Exco test revealed pitting only. This one specimen test indicates that 7010-T73651 is not susceptible to exfoliation corrosion.

C O N C L U S I O N S

1. The 7010-T73651 alloy used in this investigation is resistant to stress corrosion cracking at stress levels up to and including 35 ksi in the alternate immersion test, whereas the 7050-T73651 threshold value in the same test is 45 ksi.

Additionally, based on microstructural effects; i.e., depth of pits and extent of incipient cracking, the stress corrosion resistance of 7050-T73651 is considered somewhat better than that of 7010-T73651.

2. The 7010-T73651 is not susceptible to exfoliation.

R E F E R E N C E S

- (a) ANSI/ASTM G49, Standard Recommended Practice for Preparation and Use of Direct Tensile Stress Corrosion Test Specimen. 1979 Annual Book of ASTM Standards Part 10.
- (b) ANSI/ASTM G47, Standard Recommended Practice for Determining Susceptibility to Stress Corrosion Cracking of High Strength 7XXX Aluminum Alloy Products; *ibid.*
- (c) ASTM G34, Standard Method of Test for Exfoliation Corrosion Susceptibility in 7XXX Series Copper Containing Aluminum Alloys (Exco Test); *ibid.*
- (d) B. W. Lifka, Cooperative Test Program on Plate of 7010-T73651 and 7050-T73651, Alcoa Technical Memo, 60-RE-1007, 25 Aug 76.
- (e) M. A. Reynolds, Stress Corrosion Testing of the Aluminum Alloys Designated 7010 and AA7050, Alcan Laboratories Ltd., Report No. BR-77/6, Feb 1977.
- (f) I. Shaffer, Stress Corrosion Resistance of 7050-T73 Aluminum Alloy, Report No. NADC-75205-30 of 10 Sep 75.
- (g) B. C. Wilson, Evaluation of 7010-T73651 Plate, McDonnell Douglas Technical Report 574-654 of 4 Apr 79.

TABLE I

PROPERTIES OF 7010 AND 7050 ALUMINUM ALLOYS

COMPOSITION, WEIGHT PERCENT

	Zn	Mg	Cu	Zr	Fe	Si	Ti	Mn	Cr
7010*	6.30	2.38	1.92	0.12	0.08	0.09	0.04	0.02	<.01
7050**	6.10	2.34	2.17	0.11	0.09	0.05	0.03	0.03	0.02

SHORT TRANSVERSE TENSILE PROPERTIES

	Tensile Strength		Yield Strength		Elongation
	Ksi	MPa	Ksi	MPa	%
7010***	70	483	59	407	6
7050**	73	503	57.6	397	8

NADC-80038-60

- * Reference (e)
 ** Reference (f)
 *** Reference (g)

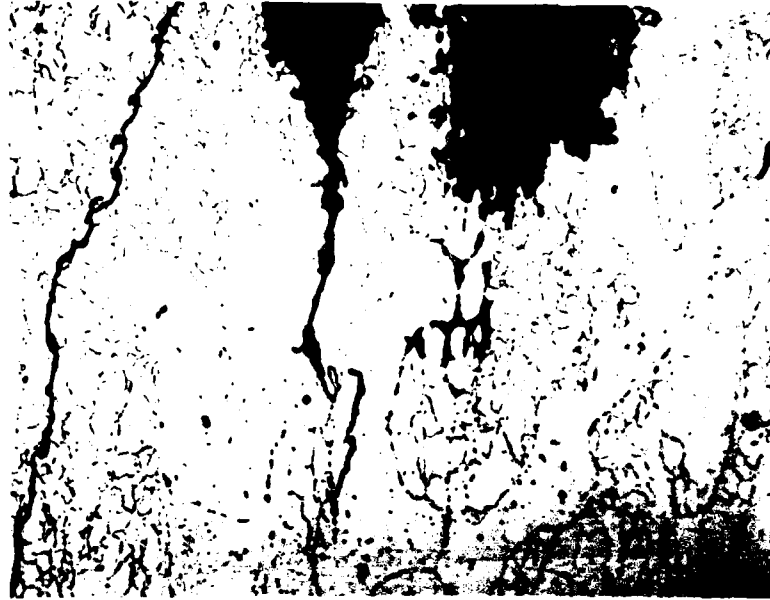
TABLE II

COMPARISON OF TEST RESULTS IN 3 1/2 PERCENT ALTERNATE IMMERSION
TEST WITH 0.125 INCH DIAMETER SHORT TRANSVERSE TENSILE SPECIMENS

Alloy	Stress		Time To Failure (Days)	
	ksi	MPa	NADC	ALCOA *
7010-T73651	25	170	(28), 2NF	---
	35	240	3NF	10NF
	45	310	(28), 2NF	(24), 9NF
7050-T73651	25	170	3NF	---
	35	240	3NF	15NF
	45	310	3NF	15NF

NF - No Failure

* Reference (d)

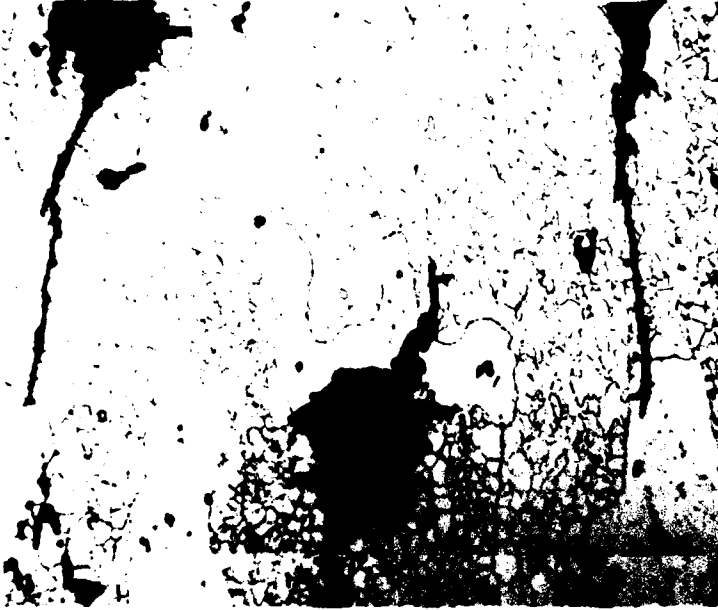


(a)



(b)

FIGURE 1 - PHOTOMICROGRAPH OF 7010-T73651 FAILURE AFTER 28 DAYS ALTERNATE IMMERSION TEST IN 3 1/2 PERCENT NaCl AT A STRESS LEVEL OF 25 ksi. KELLER'S ETCH. a) 100X, b) 400X.

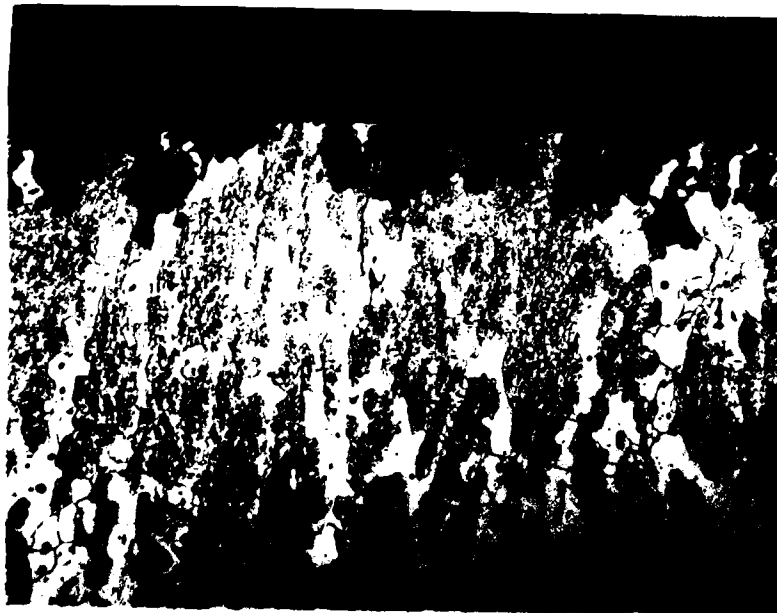


(a)

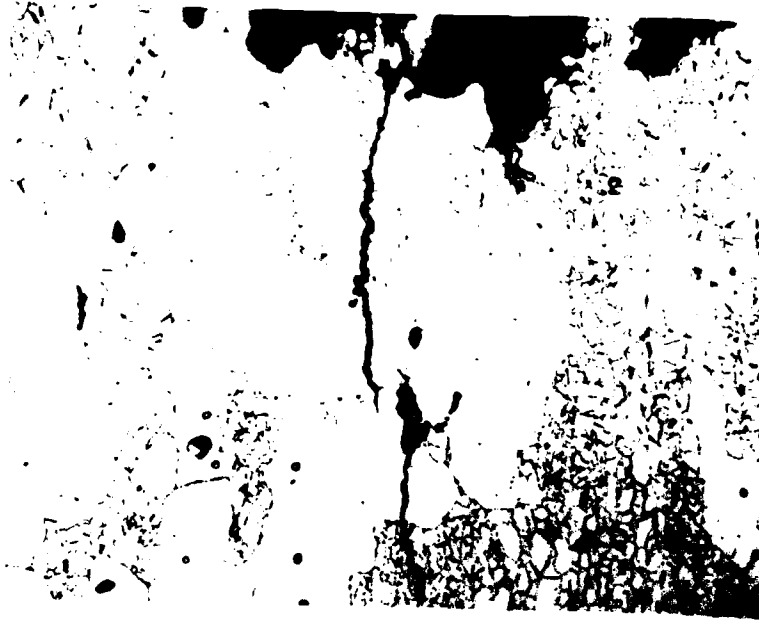


(b)

FIGURE 2 - PHOTOMICROGRAPH OF 7010-T73651 FAILURE AFTER 28 DAYS ALTERNATE IMMERSION TEST IN 3 1/2 PERCENT NaCl AT A STRESS LEVEL OF 45 ksi (310 MPa) KELLER'S ETCH a) 100X, b) 400X.



(a)



(b)

FIGURE 3 - PHOTOMICROGRAPH OF 7050-T73651 AFTER 30 DAYS
ALTERNATE IMMERSION TEST IN 3 1/2 PERCENT NaCl AT A STRESS
LEVEL OF 45 ksi. KELLER'S ETCH. a) 100X, b) 400X.

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